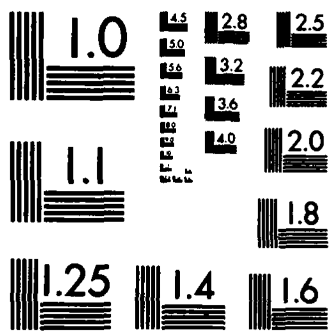
AD-A135 002   A COMPARISON OF CAPABILITY ASSESSMENT USING THE LOGRAM   1/1
AND DYNA-METRIC CO..(U) AIR FORCE INST OF TECH
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. D P SPROULL
UNCLASSIFIED   SEP 83 AFIT-LSSR-95-83   F/G 15/5   NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A135002

A COMPARISON OF CAPABILITY ASSESSMENT
USING THE LOGRAM AND DYNA-METRIC
COMPUTER MODELS

Daniel P. Sproull, Captain, USAF

LSSR 95-83

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

83 11 28 022

A COMPARISON OF CAPABILITY ASSESSMENT USING THE LOGRAM AND DYNA-METRIC COMPUTER MODELS

Daniel P. Sproull, Captain, USAF

LSSR 95-83

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER LSSR 95-83	2. GOVT ACCESSION NO. AD-A135002	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A COMPARISON OF CAPABILITY ASSESSMENT USING THE LOGRAM AND DYNA-METRIC COMPUTER MODELS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Daniel P. Sproull, Captain, USAF		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS School of Systems and Logistics Air Force Institute of Technology,WPAFB OH		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Department of Communication AFIT/LSH, WPAFB OH 45433		12. REPORT DATE September 1983 13. NUMBER OF PAGES 68
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Approved for public release: IAW AFR 190-17.

LYNN E. WOLAVER

Dean for Research and Professional Development

Air Force Institute of Technology (ATC)

Wright-Patterson AFB OH 45433

[illegible] 1983

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Recoverable Models
Inventory Management
Performance Calculation
Aircraft Availability
Capability Assessment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Thesis Chairman: Herbert A. Stewart, Major, USAF

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

LOGISTICS REQUIREMENTS ANALYSIS MODEL

The correct choice of a capability assessment model is vital in acquiring an accurate assessment of a weapon systems' wartime capability. Studies have demonstrated that the best logistical estimator of aircraft capability is the number of Fully Mission Capable (FMC) aircraft available for use in a wartime scenario. The AFLC/XRPA LOGRAM model estimates weapon system capability by estimating aircraft availability based on the percentage of wartime spares requirements provided by estimated on hand assets. Dyna-METRIC, however, estimates aircraft availability based on the number of FMC aircraft for a given stockage position. A LOGRAM data base was evaluated using Dyna-METRIC to determine differences in aircraft availability estimates. Dyna-METRIC produced a lower estimate of aircraft availability than did the LOGRAM model. Research indicated that a mixed model, using LOGRAM to develop the data base and Dyna-METRIC to provide the aircraft availability estimates would provide a blend of the strong points of each model.

LSSR 95-83

A COMPARISON OF CAPABILITY ASSESSMENT USING LOGRAM AND DYNA-METRIC COMPUTER MODELS

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

in Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

Daniel P. Sproull, BS,MA

Captain,USAF

September 1983

Approved for public release;
distribution unlimited

This thesis, written by

Captain Daniel P. Sproull

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT

DATE: 28 September 1983

COMMITTEE CHAIRMAN

READER

ACKNOWLEDGEMENTS

This thesis would not have been possible without the outstanding help provided by Mr. Mike Collier and Mr. Thomas Raether of HQ AFLC. I wish to express my sincerest thanks for their help and guidance.

I wish to thank Mr. John Plummer for his constant willingness to answer questions concerning the Create computer system.

Finally, my special thanks to my wife Susan and children for their moral support and understanding during the hours consumed in completing this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background

The Air Force Logistics Long-Range Planning Guide (LLPG) identifies several objectives of the "logistics community" through the year 2000. One of these objectives states the need to "develop a means to better identify and assess logistics requirements and capabilities [17:1]" with the strategy of "improving reporting of logistic needs as they affect unit readiness and sustainability [19:3]."

Increased attention has been focused on logistics support activities in order to appraise actual capabilities, recognizing that:

> since there will probably be a limited number of spares to work with, it is essential that the logistics community know the requirements, condition, availability, and location of these scarce assets at all times [19:3].

This paper will view the requirements aspect of forecasting logistics needs, and particularily the forecasting of spare part availability at a future time. The LLPG asserts that there is a:

> ... shortfall between peacetime procurement and the level of spares required to fully support a wartime effort. The problem has been due in part to an inadequate requirements computation process,

> leading to a poor assessment of the long range effects of near-term budgetary decisions as they pertain to operational readiness and sustainability [19:3].

It should be recognized that forecasting inventory requirements covers two areas: consumable and recoverable items, and that requirements forecasting is not identical for each type. The consumable category includes issue items or one time useage items, either incorporated into a reparable asset or directly consumed. These items are managed using economic order quantity (EOQ) calculations and will not be addressed in this paper. This paper will focus on the reparable or so-called recoverable items. Since it is estimated that these items account for some 95% of the AF spares budget, managing and forecasting their use and status are of vital concern to AFLC managers. In addition to being expensive, these items usually require long lead times for their manufacture and procurement and, thus, their requirements/deficits must be forecast to enable AFLC to adequately support future requirements to meet national objectives (6:4).

To aid in this task, AFLC utilizes the Recoverable Consumption Item Requirements Computation System (DO41), a computer based inventory system, to manage and forecast Air Force recoverable assets. This system:

> computes worldwide requirements on the basis of parts usage and stock level data collected through various other data processing systems [8:1].

The DO41 system projects future requirements by accumulating data on spares as they circulate through the recoverable assets cycle: from the warehouse to base supply, to an assembly, then removed due to failure, repaired through a repair facility and, finally, back to the warehouse for re-issue. Spares stockage and utilization rates are based on data from this cycle and are analyzed by the DO41 system, which uses this accumulation of data to produce forecasts of aircraft parts requirements for a future date (8:1).

The forecasts consist of base and depot repair rates, condemnation rates, planned procurement actions, and historical order and shipping times. The various item managers may also influence these factors to compensate for conditions not reflected in the input data. These factors are then used to compute the anticipated spares requirements and projected on hand inventory to be used in evaluating aircraft availability for a wartime scenario (4).

XRPA, Program Assessment Branch of AFLC, in an effort to evaluate AFLC's ability to support a weapons system in a future war, uses DO41 data as one of the input parameters for the Logistics Requirements Analysis Model (LOGRAM). This model, utilizing the DO41 data base, along with wartime estimates of sorties and flying hours, simulates reparable item utilization and provides estimates of reparable item shortfalls in the future wartime environment for each month

of a twelve-month war. Shortfalls are then analyzed with respect to projected requirements to ascertain a projected aircraft sortie capability (16).

Pyles and Tripp, in a RAND Corporation report, stated that an analysis of this type is invalid, since:

> In peacetime, it is very difficult to forecast whether a force has adequate logistics support resources and processes to meet its future wartime needs. The transition from peace to war so drastically changes operational demands and support processes that logistics managers cannot merely extrapolate their peacetime experience to assure adequate wartime capability [14:v].

The solution is to apply the time-stationary (steady-state) models to peacetime, with a relatively stable environment and to use a dynamic model to analyze the wartime environment. In another RAND report, John Muchstadt noted that:

> In a NATO scenario, for example, wide swings in demand rates and repair rates are to be expected as flying levels fluctuate. In such a scenario, steady-state models are likely to cause significant misallocation of stock and miscalculation of the performance to be expected from the repair and supply systems [12:v].

In a response to these conditions, RAND developed a model for the dynamic wartime environment called the Dynamic-Multi-Echelon Technique for Recoverable Item Control (Dyna-METRIC) in an effort to identify and resolve conflicts in support plans and to identify areas where peacetime performance differs from required wartime response (14:vi).

Problem Statement

Each year, AFLC is tasked by the Air Staff to provide estimates of a weapons system wartime capability for a period two years in the future. Present procedures call for analyzing spare usage data over the past 24 months and forecasting asset status for the future period. The forecasts consist of base and depot repair rates, condemnation rates, planned procurement actions, and historical order and shipping times. The various item managers may also influence these factors to compensate for conditions not reflected in the standard input data. This forecast is analyzed using the LOGRAM model (4).

When analyzing the performance of a logistics system it is vital to "come up with a universally agreed upon measure of weapons system effectiveness [15:18]." Pyles and Tripp state that the most important effectiveness measure for an aircraft system is the number of mission capable aircraft a logistics system is able to provide in support of the various war plans (15:18). LOGRAM does not evaluate weapons system performance in this manner, but by estimating the proportion of spares assets available to meet anticipated requirements (4).

What is needed, is a means of evaluating aircraft availability in a future war scenario based on mission capable aircraft. In addition to providing for the dynamic

war environment, Dyna-METRIC analysis is based on aircraft availability not on the expected value of the number of backorders. Therefore, the Dyna-METRIC model should be compared to the LOGRAM model to determine differences in aircraft availability estimates.

Research Objective

The purpose of this research is to examine future aircraft availability estimates using the LOGRAM and Dyna-METRIC computer models.

Research Question

Does the Dyna-METRIC computer model provide a statistically significant different estimate of aircraft availability than does the LOGRAM computer model?

Scope

This project will use data from the March 1982, D041 system analysis for a single aircraft type, using items identified by the D041 system as war essential. These data will then be used as the input parameters for both the LOGRAM and Dyna-METRIC assessment models to determine if the models provide different estimates of an aircraft's ability to fight in a future war. Whenever possible, identical data and conditions will be specified in each model.

CHAPTER II

LITERATURE REVIEW

Any study of this type would be incomplete without a review of applicable literature on inventory models and the assumptions behind them. Inventory models are defined as those tools which assist the inventory manager in deciding when to order, and how much of an item to order (9:43). As discussed earlier, spares, and recoverables in particular, make up the most expensive items in the support of Air Force weapons systems. The Air Force utilizes various computer inventory models to effectively manage spares. Managing quantity alone is not sufficient; the location of the spare parts must also be considered. The driving factors of inventory policy encompass item failure rate, pipeline repair time, and the underlying flying hour program (9:44).

The USAF supply system is based upon a two-echelon philosophy; items are distributed from a depot warehouse (first echelon) to a base or several bases (second echelon) where the parts are used (17:123). Therefore, all models covered in this review will be of the multi-echelon type.

Since the driving inputs for the models under review in this study are based on data from the DO41 system, the

system assumptions and output data will be analyzed. The LOGRAM model itself will then be viewed, followed by the Dyna-METRIC model along with its evolution from earlier models. Finally, other similar models will be discussed in relation to their applicability toward aircraft capability assessment and relationship to the capability models under study.

Consumption Item Requirements Computation System (DO41)

The purpose of the DO41 system is "to compute worldwide replenishment spares requirements for the USAF and other services within the Department of Defense (DoD) [1:2-46]." The DO41 system compiles data on Air Force recoverable items, on a quarterly basis, from data files obtained from the various Air Logistics Centers (ALC) and AFLC data bases. Each computation provides a time-phased forecast of recoverable spares status for up to 25 quarters into the future. It is this time-phasing that enables AFLC to project requirements and recoverable item status for future fiscal years (1:2-27). Replenishment requirements are those spares needed to resupply the USAF when initially procured spares are consumed or usage increases. Spares requirements are those items set aside to be used when an in-use item fails. The quarterly estimates incorporate data on all spares activities such as procurement, repair,

reclamation, or modification. The system computes whether there is an asset shortage or overage by "considering all requirements, assets which will be available to satisfy those requirements, as well as assets which will require repair [1:2-46]." An analysis of the methods used by the DO41 system in accumulating recoverable asset data can be found in "A Comparative Analysis of the DO41 System and Time Series Analysis Models for Forecasting Reparable Item Generations" by Christensen and Schroeder (3) or "A Comparative Analysis of the DO41 Single Moving Average and Other Time Series Analysis Forecasting Techniques" by Brantley and Loreman (2).

Logistics Requirements Analysis Model (LOGRAM)

The purpose of the LOGRAM model is to "Compute OWRM (Other War Reserve Material) deficits for a period of time (usually 12 months) for all items, war essential to a weapons system [20:1]" with the added requirements to:

1. Apply current assets to the war requirements.

2. Compute values per flying hour.

3. Show actual levels and condemnations and the dollar values, by month, that determine the OWRM deficit.

4. Display any data used in the computation per stock number, totaled for a group of stock numbers, or totaled by weapons system.

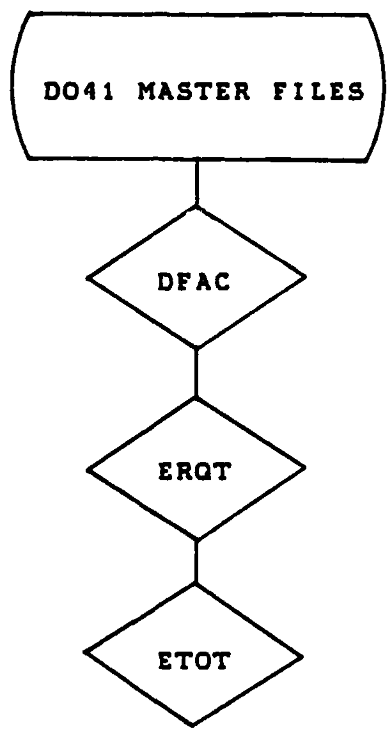
5. Be able to change any data used in the computation (flying hours, price, demand rate,

etc.) for a stock number, a group of stock numbers, or all stock numbers for a weapons system.

6. Be able to eliminate a part, or parts from the computation, such as not computing overall requirements.

7. Be able to select items by category, such as stock numbers with lead times over 2 years, or OWRM deficit cost greater than 1 million dollars [20:2].

The LOGRAM model consists of three main modules (see Figure 1).



LOGRAM PROGRAM HIERARCHY (20)

Figure 1.

The D-FACTOR (DFAC) module extracts data on war essential spares from the D041 master data bank for a particular weapons system. These data are then sorted and placed in a format for direct input into the E-REQUIREMENT (ERQT) module, which computes the actual projected requirements for the period in question under the following assumptions:

1. Only three months peacetime lead-in is required to compute an accurate depot repair cycle.

2. Base and depot levels are computed using the following models program.

3. Depot condemnations are computed against slipped reparable generations.

4. Non-job routed stock levels are not computed.

5. Peacetime rates and percents are accurate during wartime.

6. Wartime O&ST (order and shipping time) days, number of users, depot repair cycle days, and production deliveries will be used when available.

7. Maximum wartime is 12 months [20:2].

The output of the ERQT module serves as the input into the E-TOTAL (ETOT) module, which analyzes the requirements output from the ERQT, plus those assets on order, incorporating historical repair, failure and data.

The ETOT module assumes that:

1. On order assets will be delivered at the beginning of the war (D-Day).

2. The peak difference, in a month, between wartime and peacetime requirements is the WRM (war reserve material) requirements.

3. OWRM requirements are equal to the WRM requirements reduced by the D041 prepositioned requirements.

4. Peak wartime requirement is within the time period limited to the lesser of war leadtime or 12 months.

5. Due in assets and additive requirements are not significant quantities [20:3].

Introduction to Dyna-METRIC

Dyna-METRIC has been developed by the RAND Corporation in an effort to model logistic support capabilities under demanding dynamic scenarios. Dyna-METRIC grew out of the realization that the stable, "steady-state" methods of analyzing the peacetime environment did not adequately approximate the dynamic wartime environment. The use of these "steady-state" models could lead to an overstatement or understatement of wartime spares requirements, potentially erroneous war reserve spares kits for squadrons and, in general, an inaccurate assessment of logistics policies (10:iii).

Before describing the Dyna-METRIC model, we must first examine the development of the "steady-state" models which serve as the background of Dyna-METRIC.

(S-1,S) Inventory Policy

This policy, by Feeney and Sherbrooke, states that in a "continuous review (S-1,S)" inventory policy, whenever there

is a demand for 'x' number of units, an order is placed immediately for that number of units. This automatic reorder action restores the total stock on hand plus newly ordered items, less backorder to the desired spare stock level(s) (7:1).

Feeney and Sherbrooke further defined the "steady-state" nature of the inventory system by applying Palm's QUEUING theorem to inventory: "if demand is Poisson then the number of units in resupply in the steady state, 'x', is also Poisson for any distribution of resupply [7:2]."

This policy provides a reasonable representation of the supply activities at base level. Needed was a means of incorporating the depot into the inventory process and of adjusting to a dynamic, non-steady environment.

METRIC

An improvement to the (S-1,S) model incorporated the multi-echelon aspects of a supply system in Sherbrooke's: METRIC: A Multi Echelon Technique for Recoverable Item Control.

METRIC is a model of a base-depot supply system. When an item fails at the base level there is a probability 'r' that it can be repaired at the base according to a repair time probability and a (1-r) probability that it must be

returned to depot for repair, following another repair distribution. The latter case also creates a resupply request for a replacement part from the depot (17:v).

The goal of the METRIC model is to "optimize system performance for specified levels of system investment (17:2)."

METRIC "optimizes system performance" subject to the following:

1. System objective often minimizing the expected number of backorders.(Minimize the sum of all back orders for all bases for a given weapon system with a back order defined as an "unsatisfied demand at base level, e.g., a recoverable item is missing on an aircraft.")

2. Compound Poisson Demand.

3. Demand is stationary over the production period.

4. Decision on where to repair is to be accomplished depends on the complexity of the repair only.

5. Lateral supply is ignored.

6. System is conservative. (This assumes that all items are reparable (i.e., no condemnation)).

7. The depot does not batch units of a recoverable item for repair unless there is an ample supply of serviceable assets. Model assumes repair begins when a reparable part arrives at the depot from a base and higher cost items are repaired first (since they are likely to be in short supply) [17:6-11].

8. Recoverable items may have different essentialities.

9.Demand data from different bases can be pooled [17:12].

Although METRIC was an improvement over the (S-1,S) process, several areas remained to be addressed. The dynamic wartime environment and the relationship between a reparable and those parts used to repair it, still remained to be addressed.

MOD-METRIC

In a further refinement of the multi-echelon inventory system, John Muchstadt developed MOD-METRIC to model the control of a multi-item, multi-echelon, multi-indenture inventory system. An indenture describes the relationship between an assembly and its components (13:472).

The objective of MOD-METRIC is "to minimize the expected base backorders for the end item subject to an investment constraint on the total dollar allocated to the end item and its components [13:475]."

In the METRIC model all backorders are treated as equally undesirable. MOD-METRIC looks at the shop replaceable unit (SRU) as well as the line replaceable unit (LRU). As a result of this different viewpoint of considering multi-indentures, the model provides a better approximation of the real world (9:45).

MOD-METRIC makes the following assumptions:

1. A stationary compound Poisson probability distribution describes the demand process for each item.

2. There is no lateral supply between bases.

3. A failure of one type of item is statistically independent of those that occur for any other type of item.

4. Repair times are statistically independent.

5. There is no batching of items before repair is started on an item (infinite channel queueing assumption).

6. The level at which repair is performed depends only on the complexity of the repair (and not on existing workload).

7. No cannibalization takes place [13:474].

The significant enhancement of MOD-METRIC is that it highlights the differences between LRU's and SRU's. A backordered LRU might ground an aircraft, but a back ordered SRU might only delay the repair of an LRU in the base maintenance cycle (13:475). Where METRIC looked upon all backorders as equal, MOD-METRIC "minimizes total expected backorders subject to a constraint on investment in all LRU's and SRU's [13:481]."

MOD-METRIC, then, completed the ground work needed to fully analyze the aircraft availability problem. An adequate representation of the multi-echelon, multi-indenture inventory system was now ready to be adapted to model the dynamic wartime environment (5:17).

Dyna-METRIC

In a Rand Report, Hillestad and Carrillo noted that

these steady state models have proved adequate for the peacetime environment. However, there are situations in which:

> "the transient behavior is most important. A dramatic example of this is the potential dynamic behavior exhibited by demands and service in the deployment of an Air Force squadron at the onset of a conflict. Demands for components may suddenly jump very high relative to the previous peacetime activity of the squadron and then decay gradually or abruptly due to the attrition of the aircraft in the squadron...the initial service rate may be near zero, as the already deployed unit awaits the airlift of specialized personnel and test equipment to repair broken components, gradually increase to its full wartime service capability, and suddenly drop to near zero as a result of damage in an airbase attack [10:1].

The Dyna-METRIC model was developed to assess and predict aircraft readiness by analyzing logistics resources, those involved with component repair and supply. The objective of the model is to attempt to minimize loss of aircraft availability due to shortages of operable components. This can only be achieved if there is a sufficient supply of these parts in the supply pipeline, or those parts in various states of repair and shipment (11:2-3). When there is an insufficient number of spare components,

> holes will appear in aircraft; these "holes" may or may not affect the ability of the aircraft to perform its mission, depending on the mission essentiality of the missing component [11:3].

Dyna-METRIC considers spare components at bases and

depots, personnel and repair equipment, and transportation resources. These considerations are vital, since a unit requires these resources to support " a highly dynamic flying program [11:3]."

The same problems face the logistics manager under both the steady state and nonstationary cases: how many spares to provide against back orders and what level of performance can be achieved from a level of investment in spares? Another aspect which METRIC and MOD-METRIC models fail to consider is that of cannibalization. Cannibalization is the process of removing a properly functioning part from a NMCS aircraft, one not mission capable-supply, to repair another aircraft. The NMCS aircraft serves as an additional source of spare parts. Dyna-METRIC permits cannibalization for its' computations, thereby providing a more realistic evaluation of aircraft availability (10:2-3).

Dyna-METRIC makes the following assumptions:

1. The repair and demand processes are independent.

2. Component data are not unit dependent.

3. There is no lateral transfer of supply between bases.

4. Failures are based upon demanded flying hours rather than actual hours flown.

5. There is only full and instantaneous cannibalization of SRU's and LRU's or no cannibalization. (This is being changed to allow selected cannibalization in a future release).

6. Demands for part decrease as aircraft are attrited.

7. The depots are considered as infinite sources of supply [18:12-3].

Dyna-METRIC has:

the ability to deal directly with transient demands [surges] placed on component repair and inventory support caused by dynamic parameters in a scenario (sortie rates, mission changes, phased arrival of component repair resources, interruptions of transportation,etc.) [11:4]."

This is accomplished through a series of dynamic equations describing the component repair queuing systems. Also included in the model are equations describing components and sub-components (indenture) and multi-echelon repair capability. Out of these equations, the time-dependent nature of the dynamic scenario can be analyzed to assess "mission readiness of the aircraft supported [11:4-5]."

An indepth analysis of the model mathematics can be found in Models and Techniques for Recoverable Item Stockage when Demand and the Repair Process are Nonstationary--Part I: Performance Measurement (10) by Hillestad and Carrillo or Dyna-METRIC: Dynamic Multi-Echelon Technique for Recoverable Item Control (11) by Hillestad.

Conclusion

It is evident from the literature that it is vitally

important that the correct model be chosen for the particular problem under investigation. The "steady-state" models are not suitable for evaluating a wartime environment, due to their inability to react to and properly evaluate a logistics system under the dynamic wartime conditions. Therefore, Dyna-METRIC is the present answer for analysing the dynamic scenarios of the war environment to determine how well our logistics systems support a weapons systems' ability to perform its' wartime mission as measured by number of Fully Mission Capable (FMC) aircraft.

CHAPTER III

RESEARCH METHODOLOGY

Overview

Since the basic assumptions and scenario data have a significant effect on any capability assessment, the assumptions and data requirements of both the LOGRAM and Dyna-METRIC models were examined prior to comparing actual capability estimates. For this purpose, this chapter examines the chosen experimental design, location and description of research data, and the research question evaluation techniques used in the comparison of these two aircraft capability assessment models.

Experimental Design

AFLC/XRPA has used the LOGRAM model for a number of years for all current weapons systems. LOGRAM provides AFLC with a weapons system capability estimate based on a system wide perspective. Model output is in the form of total weapons system (i.e. F-16) war essential reparable parts requirements versus total expected assets on hand, both represented by their respective total dollar values, for each month of a twelve-month war. From the analysis

of these totals, an estimate is derived which planners use to assess a weapons systems' war capability (4).

Dyna-METRIC has evolved over from a series of peacetime analysis models into one of the best analytic tools in evaluating a logistics systems effect on weapons systems' mission capability. Dyna-METRIC also views a weapons systems' reparable spares requirements and anticipated deficits; but, only in the analysis of their effect on an aircrafts' ability to perform its' assigned mission, by estimating the number of FMC (Fully Mission Capable) aircraft. Dyna-METRIC provides capability estimates for user defined time increments, such as daily, weekly, or monthly (16).

In order to maintain a common output data base for research evaluation, a tactical aircraft, the F-16 and a monthly Dyna-METRIC output format, will be utilized for research analysis.

<u>Data Base</u>

The data used in this research was obtained utilizing the DFAC and EROT modules of the LOGRAM assessment program. These modules extracted the required information from the DO41 data base for the F-16 weapons system. This data encompassed all reparable parts peculiar to the F-16 as well as parts used in common with other similar weapons systems,

identified by the weapons system manager as critical for the F-16's war mission (18).

The DFAC-ERQT output was in the proper format for input into the remaining LOGRAM modules (see appendix A). Since Dyna-METRIC data requirements and input formats differ substantially from those used by LOGRAM, a series of Fortran programs were written to translate the necessary LOGRAM data into the Rand format necessary for Dyna-METRIC version 3.04 (see Appendix B).

The conversion process identified several areas of data incompatibility between LOGRAM and Dyna-METRIC. For several stock numbers the LOGRAM data base contained a value of zero. Although these values created no difficulties for the LOGRAM model, they were unacceptable inputs for Dyna-METRIC. Since the true values for the missing data could not be determined, the minimum values for peacetime order and shipping time and item repair/test time were used for Dyna-Metric.

LOGRAMS' view of a weapon system from a total system viewpoint determined other inputs for Dyna-METRIC. Since LOGRAM does not consider interruptions in transportation systems in its' computations, transportation systems were assumed to be operable throughout the conflict, and thus, a remove, repair, and replace (RRR) maintenance policy was in existence throughout the conflict scenario, for all parts.

The reparable demand rates were already adjusted for wartime so a peacetime/wartime linearity factor of 1 was used with a Poisson pipeline distribution. Aircraft attrition was addressed by changing total aircraft levels at monthly intervals.

Research Approach

The purpose of this research was to determine if the LOGRAM and Dyna-METRIC assessment models provide significantly different estimates of the F-16's war capability. This comparison was accomplished using the criteria of meeting planned sortie requirements for a future wartime scenario.

The basic approach was to:

(1) Run the LOGRAM model using the March 1982 F-16 data from the DO41 system and obtain the completed F-16 capability assessment results.

(2) Run Dyna-METRIC 3.04 using the modified LOGRAM input data converted by the previously discussed programs and obtain the resulting F-16 capability assessments.

(3) Run Dyna-METRIC using varying sorties per day and and sortie length to determine research sensitivity to Dyna-METRIC scenario assumptions and their effect of research question evaluation.

(4) Analyze model results on a month by month basis (twelve-month war scenario) to determine assessment model differences (if any).

Evaluating Research Question

The research question is: Does the Dyna-METRIC computer model provide a statistically different estimate of a weapons systems' wartime availability than does the LOGRAM computer model? To answer this question, the following statistical hypothesis will be evaluated :

H_0 : The LOGRAM and Dyna-METRIC model provide identical capability estimates.

H_1 : The Dyna-METRIC assessment model provided a higher or lower estimate of aircraft capability than does the LOGRAM model.

Since Dyna-METRIC provides aircraft availability estimates for only nine points in time, the comparison of the two models will be based on the end of month estimates for the first nine months of the war scenario. To evaluate the differences (if any) between the model estimates, a small sample T-test will be used in establishing any differences at a confidence level of 90 percent.

F-16 AIRCRAFT CAPABILITY (%)

Month of War	LOGRAM	Dyna-METRIC
1	%	%
2	%	%
3	%	%
4	%	%
5	%	%
6	%	%
7	%	%
8	%	%
9	%	%

Table 1

Model Differences

Since no two models view the data in the same manner, the following lists some of the differences noted between LOGRAM and Dyna-METRIC:

1. Condemnations - Dyna-METRIC does not include items that are no longer serviceable.

2. Transportation - LOGRAM does not address transportation issues for spare parts or the effects of delays in setting up on-site repair capability at a forward operating location.

3. Attrition - LOGRAM does not address changes in aircraft numbers due to combat loss.

4. Depot Stock - Dyna-METRIC assumes depot always has inventory where LOGRAM takes depot stock levels and production leadtimes into consideration.

5. Aircraft Status - LOGRAM looks only at the total parts requirements, not their effects on aircraft status.

6. Assessment Intervals - Dyna-METRIC output provides assessments for only 9 time intervals, such as status on day 30 , not an average for the month.

7. Cannibalization - LOGRAM does not address cannibalization of parts since it does not analyze capability from a FMC aircraft viewpoint.

8. Indenture - LOGRAM assumes that all parts are of equal importance , assuming that the higher priced items are the more important and does not differentiate between LRU's and SRU's.

All of these differences have been taken into consideration in translating the LOGRAM data base and wartime scenario for this research.

CHAPTER IV

RESULTS

Overview

This chapter presents the research results in both a tabular and graphic format. Table 2 presents the Dyna-METRIC results using varying sortie rates with constant flying hours per sortie. Table 3 presents the Dyna-METRIC results obtained from varying the flying hours per sortie with a constant sortie rate. Table 4 presents the LOGRAM estimate of the F-16 aircraft availability for an FY84 war scenario. Table 5 addresses the research question by comparing the LOGRAM and Dyna-METRIC assessment results on a month by month basis, showing estimates of aircraft availability. Figure 2 presents a graphical representation of this comparison.

The analysis of results will concentrate on the interpretation of the tables and graphs in light of the research question and problem statement so that a complete understanding of the research results can be achieved.

Sensitivity Analysis

Table 2 presents the analysis of the sensitivity of the Dyna-METRIC results to changes in the daily number of sorties per aircraft.

Dyna-METRIC Results					
Flying Hours per Sortie------ 2.5					
Daily sorties per aircraft					
Month	1.6	1.8	2.0	2.2	2.4
1	82.87	80.91	78.79	76.84	73.08
2	78.61	76.17	73.92	71.48	69.98
3	77.84	75.45	72.85	70.46	69.06
4	77.98	75.51	73.05	70.58	69.55
5	77.83	75.22	72.83	70.22	69.57
6	77.83	75.29	72.75	70.21	70.44
7	77.35	74.81	72.26	69.72	69.47
8	77.57	75.14	72.43	70.00	68.11
9	77.84	75.41	72.97	70.27	58.38
Mean	78.41	75.99	73.54	71.09	68.63
Std Dev	1.61	1.77	1.91	2.09	3.84
Test val	3.03	2.82	----	2.59	3.36

Table 2

This table shows the Dyna-METRIC results using 2.5 flying hours per aircraft and a base line value of 2.0 sorties per aircraft-plus or minus ten and twenty percent. A small sample T-test was used with a critical T-value of 1.746 obtained from a table of critical values of t.

With this value, the test for a significant difference can be made. The small sample T-test indicates that if the test value is greater than the critical T-value, there is a significant difference at the selected confidence level.

As shown in Table 2, a ten or twenty percent change in either direction proved to be significantly different from the baseline value at a confidence level of 90 percent, as indicated by the test values larger than the charted critical T-value.

In additional model scenario sensitivity testing, Table 3 presents the results of varying the flying hours per sortie while holding daily sorties per aircraft constant. As in the previous test, a ten or twenty percent difference in the base line value produced a test statistic greater than the computed T-value, again showing significantly different results as a result of a ten or twenty percent change in model parameters.

Dyna-METRIC RESULTS					
Daily sorties per Aircraft---- 2.0					
Flying hours per Sortie					
Month	2.0	2.25	2.5	2.75	3.0
1	84.01	81.40	78.79	76.35	73.74
2	80.11	76.92	73.92	70.73	67.54
3	79.44	76.25	72.85	69.66	66.47
4	79.42	76.34	73.05	69.75	66.46
5	79.34	76.09	72.83	69.57	66.30
6	79.45	75.98	72.75	69.52	66.05
7	79.13	75.83	72.26	68.96	65.65
8	79.19	75.95	72.43	69.19	65.95
9	79.46	76.22	72.97	69.46	66.21
Mean	79.95	76.77	73.54	70.35	67.15
Std dev	1.46	1.66	1.91	2.17	2.38
Test val	3.96	3.82	----	2.39	2.98

Table 3

Data Analysis

The results of the LOGRAM model are presented in Table 4

LOGRAM RESULTS			
MONTH	GROSS RQMT(1000$)	DEFICIT(1000$)	PERCENT
1	349,691	42,721	87.78
2	365,423	50,420	86.20
3	366,820	51,198	86.04
4	368,270	51,891	85.91
5	369,403	52,478	85.79
6	370,323	53,049	85.67
7	371,105	53,541	85.57
8	371,983	54,129	85.45
9	372,386	54,223	85.44

Table 4

Shown are the assessment results for a nine month period. The gross requirements contain the total dollar value (in thousands) of all parts looked at by LOGRAM for the period under investigation. The deficit (or the do . r value of the expected number of backorders) is computed by subtracting the value of the estimated on-hand assets from

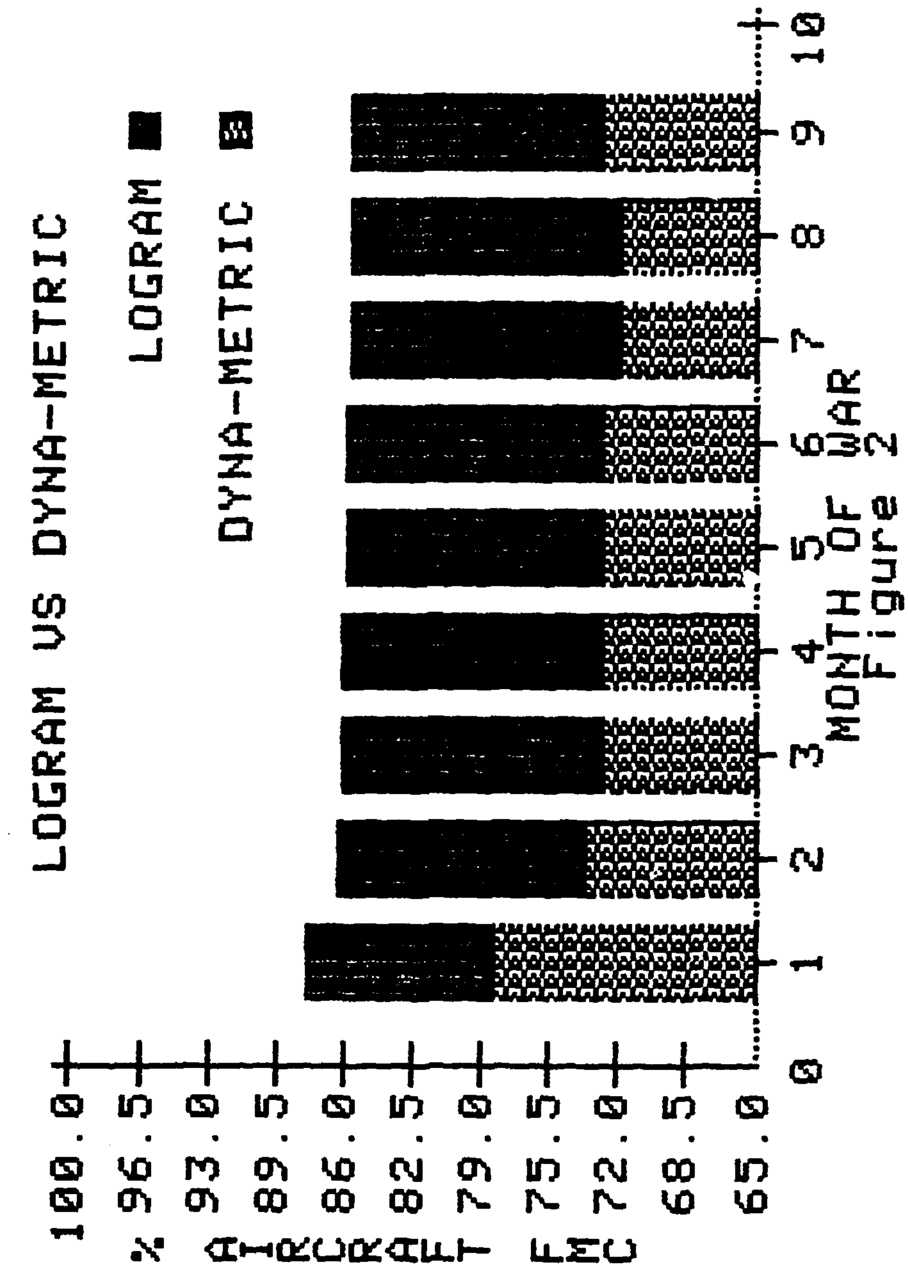
the computed gross requirements. The final LOGRAM capability estimate is then the percentage of the gross requirement which can be satisfied by the estimated on hand assets.

The evaluation of the research question: Does the Dyna-METRIC computer model provide a statistically significant different estimate of aircraft availability than does the LOGRAM computer model?, is presented in Table 5 and Figure 2.

As stated earlier, the extracted critical T-value was 1.746. The comparison showed that the Dyna-METRIC baseline estimate provided a significantly lower estimate of the F-16s' wartime availability than LOGRAM using the LOGRAM data base and scenario. In an extension of the Dyna-METRIC sensitivity analysis discussed earlier, a comparison of the most optimistic Dyna-METRIC results with the LOGRAM results, again showed that Dyna-METRIC provided a lower estimate of aircraft availability at a 90% confidence level.

LOGRAM vs DYNA-METRIC			
	LOGRAM	DYNA-METRIC	
Month	% FMC	% FMC baseline	% FMC optimistic
1	87.78	78.79	84.01
2	86.20	73.92	80.11
3	86.04	72.85	79.44
4	85.91	73.05	79.42
5	85.79	72.82	79.34
6	85.67	72.75	79.45
7	85.57	72.26	79.13
8	85.45	72.43	79.19
9	85.44	72.97	79.46
Mean	85.99	73.54	79.95
Std Dev	.68	1.91	1.46
Test val		12.45	12.25

Table 5


LOGRAM VS DYNA-METRIC
LOGRAM
DYNA-METRIC
% AIRCRAFT FMC
100.0
96.5
93.0
89.5
86.0
82.5
79.0
75.5
72.0
68.5
65.0
0
1
2
3
4
5
6
7
8
9
10
MONTH OF WAR
Figure 2

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of Research

The primary emphasis of this research effort has been the comparison of the capability assessments provided by the AFLC/XRP LOGRAM model and the RAND Dyna-METRIC model. The prime difference between the two models is in their method of computing aircraft capability estimates. LOGRAM computes capability based on the estimated percentage of assets available to meet estimated demands. The Dyna-METRIC model computes capability based on the number of Fully Mission Capable aircraft for a given wartime scenario and stockage position.

The methodology used to accomplish this research involved running the LOGRAM model utilizing the LOGRAM compiled data base from the AFLC DO41 system. This data base was then converted into a Dyna-METRIC compatible format and then input into Dyna-METRIC version 3.04.

The results of this research indicated that using the DO41 based LOGRAM data base Dyna-METRIC provided a significantly lower estimate of the F-16s' war capability than did the LOGRAM model, 73.54% versus 85.99%

Conclusions of the Research Effort

The research results indicate that the Dyna-METRIC model provides a significantly lower estimate of the F-16s' wartime availability than does the LOGRAM model. This result is not surprising due to the LOGRAM assessment methodology. In viewing capability in terms of total dollar value, there is an implicit assumption that if an 85% stockage rate (fill-rate) is indicated, that this assumes that the remaining 15% of the backorders are concentrated in 15% of the aircraft.

Dyna-METRIC, on the other hand, views these backorders as they affect individual aircraft. Dyna-METRIC directly evaluates the effects of a backorder on mission capability. In analyzing capability based solely on dollar value, more emphasis is placed on large value items ignoring the fact that, many low cost reparable or even EOQ items could effectively ground all aircraft while the gross dollar value of the backorders would indicate a much greater number of FMC aircraft than would actually exist.

The key result of this research is a reaffirmation of the need to choose the correct analysis criteria when deciding upon a tool to estimate a weapons systems' war capability. The key to any analysis of this type should be how well the spares stockage policy affects individual

aircraft, not the number or value of the expected number of weapons system backorders.

Recommendations

It seems apparent that for an actual weapons system capability assessment, the LOGRAM output is somewhat inadequate. Estimates based solely on dollar values could easily overlook a critical item or class of items of low cost, but highly critical to maintaining a FMC weapons system.

Despite this shortcoming, LOGRAM does pull together a vast amount of excellent information for its' computations. Dyna-METRIC while providing more realistic capability estimates lacks the ability to compile its own data base, it must be provided. Neither model can stand alone.

The answer is a capability assessment based on a combination of the output of both models. LOGRAM should be utilized to determine the initial and follow-on stock levels, incorporating war reserve material (WRM), peacetime operating stock (POS), assets on order, and estimated wartime deliveries. These stockage positions should then be used as the input data base for Dyna-METRIC.

The key is not that LOGRAM is better than Dyna-METRIC, but that a combination of the two model would provide a better analysis of the F-16s' or any other weapons systems'

war mission capability as measured by aircraft availability.

Suggestions for Further Research

This study examined only the F-16 weapon system. Other weapon systems should be evaluated using the LOGRAM-Dyna-METRIC comparison to insure that the conclusions reached during this research are valid.

The DO41 and the resultant LOGRAM data base contained several areas of incomplete data, such as missing repair rates and order and ship times. An effort should be made to investigate the reasons for this lack of proper information to enhance the possibilities of obtaining accurate capability assessments.

The Dyna-METRIC sensitivity study indicated that the model results were extremely sensitive to relatively small changes in the scenario parameters. A study should be made to evaluate LOGRAMs' sensitivity to similar changes in war scenario data.

The LOGRAM data base treats each item as an LRU, a line replaceable unit and as such, each item is as critical as another, relative to cost. An area of further research would be to reevaluate the LOGRAM data base to identify the LRU-SRU (shop replaceable unit) relationships and re-evaluate this data base using Dyna-METRIC. This study would then determine the backorders which affect the LRUs

undergoing repair and not indicate a NMCS aircraft.

Final Comment

Our mission is to be ready to fly airplanes in wartime. We, therefore, cannot afford to evaluate our logistics system using any other criteria than the number of mission ready aircraft provided by our support systems and personnel.

APPENDIX A

LOGRAM DATA FORMATS

DFAC-ERQT OUTPUT

TYPE 01		CHAR	LNG	END POS
Type Record "01"		N	2	2
ALC Code		A	2	4
Stock Number		AN	15	19
Item Name		AN	10	29
Unit Price	9(7)V99	N	9	38
Unit Repair Cost	9(7)V99	N	9	47
Administrative Leadtime		N	1	48
Production Leadtime		N	2	50
Base Repair Cycle Days		N	3	53
Depot Repair Cycle Days		N	3	56
Order & Shipping Time Days		N	2	58
Depot Stock Level Days		N	2	60
Overhaul Stock Level Days		N	2	62
Depot Floating Stock Level (NJR)		N	3	65
Number of Users		N	3	68
DO41 Prestocked Rqmt		N	7	75
WRM - Buy Rqmt		N	6	81
War Leadtime		N	2	83
War Production Deliveries	(12x4)	N	48	131
Item Essentiality Code		AN	3	134
War Depot Repair Cycle Days		N	3	137
War Order & Shipping Time Days		N	2	139

Negotiated Stock Level	(5x3)	N	39	178
PDM Non Job Routed Percent		N	3	181
Engine Overhaul Non Job Routed %		N	3	184
MISTR Non Job Routed %		N	3	187
System Management Code		AN	4	191
Job Routed Stock Level Days		N	2	193
Base Processed Percent	(3x3)	N	9	202
Depot Demand Rate	(3x5)	N	15	217
PDM JR Wearout %	(3x3)	N	9	226
PDM NJR Replacement %	(3x3)	N	9	235
Base Repair Rate	(3x5)	N	15	250
Base Condemnation %	(3x3)	N	9	259
Engine Job Routed Wearout %	(3x3)	N	9	268
Engine NJR Replacement %	(3x3)	N	9	277
Depot Overhaul Condemnation	(3x3)	N	9	286
MISTR Wearout Percent	(3x3)	N	9	295
MISTR Non Job Routed Replacement %	(3x3)	N	9	304
Total Demand Rate	(3x5)	N	15	319

Type 88	CHAR	LNG	END POS
Record Type	N	2	2
Assets - Serviceable	N	9	11
- Unserviceable	N	9	20
- On-order	N	9	29
- WRM - Serviceable Base	N	6	35
- WRM - Serviceable Depot	N	6	41
- WRM - Unserviceable Depot	N	6	47
- On Order Funded - WRM	N	6	53
- On Order Contract - WRM	N	6	59
- Due-In Serviceable	N	6	65
- Due-In Unserviceable	N	6	71
- Due-In TOC	N	6	77
Wartime Number of Users	N	3	80
Additive Requirement	N	6	86
Item Manager	AN	3	89
SOR & Percents XX999 occurs 7 times	AN	35	124
PMC	AN	2	126
Unit Repair Manhours	N	6	132
Equipment Specialists	AN	2	134
Peacetime Depot Repair Cycle Segments (3x5)	N	15	149
War Depot Repair Cycle Segments	N	15	164
Unserviceable Depot	N	6	170

Unserviceable Intransit	N 6	176

APPENDIX B

LOGRAM DATA BASE TRANSLATION PROGRAMS

DATA BASE TRANSLATION PROGRAM

```
$       IDENT:WP0354,AFIT,SPROULL
$       LIMITS:15,50K,,15K
$       OPTION:FORTRAN
$       FORTY:NFORM,NLNO
C=====================================================
C=====================================================
C
C  THIS PROGRAM READS A LOGRAM DATA TAPE AND TRANSLATES
C    REQUIRED DATA INTO A DYNA-METRIC VERSION 3.04
C    COMPATIABLE FORMAT
C
C=====================================================
C=====================================================
C
C  THE FOLLOWING LIST PROVIDES THE LOGRAM NAMES FOR
C     VARIABLES USED IN THE FOLLOWING PROGRAM
C
C=====================================================
C
C
C
C         REC            RECORD TYPE
C         ALC            ALC CODE
C         STOCKN         STOCK NUMBER
C         NAME           ITEM NAME
C         UPR            UNIT PRICE
C         URC            UNIT REPAIR COST
C         ADL            ADMINISTRATIVE LEADTIME
C         PL             PRODUCTION LEADTIME
C         BRCD           BASE REPAIR CYCLE DAYS
C         DRCD           DEPOT REPAIR CYCLE DAYS
C         OSTD           ORDER AND SHIPPING TIME DAYS
C         DSLD           DEPOT STOCK LEVEL DAYS (NJR)
C         OSLD           OVERHAUL STOCK LEVEL DAYS (NJR)
C         DFSL           DEPOT FLOATING STOCK LEVEL
C         NUM            NUMBER OF USERS
C         D041PR         D041 PRESTOCKED REQUIREMENT
C         VRMBR          VRM- BUY RQMT
C         VLD            VAR LEADTIME
C         VPD(12)        VAR PRODUCTION DELIVERIES
```

```
C          IEC              ITEM ESSENTIALITY CODE
C          VDRCD            WAR DEPOT REPAIR CYCLE DAYS
C          VOST             WAR ORDER AND SHIPPING DAYS
C          NSL(13)          NEGOTIATED STOCK LEVELS
C          PNJRP            PDM NON JOB ROUTED %
C          EONJRP           ENGINE OVERHAUL NIN JOB ROUTED %
C          MNJRP            MISTR NON JOB ROUTED %
C          SMC              SYSTEM MANAGEMENT CODE
C          JRSLD            JOB ROUTED STOCK LVL DAYS
C          BPP(3)           BASE PROCESSED %
C          DDR(3)           DEPOT DEMAND RATE
C          PJWP(3)          PDM JR WEAROUT %
C          PNRP(3)          PDM NJR REPLACEMENT %
C          BRR(3)           BASE REPAIR RATE
C          BCP(3)           BASE CONDEMNATION %
C          EJWP(3)          ENGINE JR WEAROUT %
C          ENRP(3)          ENGINE NJR REPLACEMENT %
C          DOCP(3)          DEPOT OVERHAUL CONDEMNATIONS %
C          MWP(3)           MISTR WEAROUT %
C          MNRP(3)          MISTR NJR REPLACEMENT %
C          TDR(3)           TOTAL DEMAND RATE
C          AS               ASSETS- SERVICEABLE
C          AU                     - UNSERVICEABLE
C          AO                     - ON ORDER
C          AWSB                   - WRM - SERVICEABLE BASE
C          AWSD                         - SERVICEABLE DEPOT
C          AWUD                         - UNSERVICEABLE DEPOT
C          AWOOF                        - ON ORDER FUNDED
C          AWOOC                        - ON ORDER CONTRACT
C          ADIS                   - DUE IN SERVICEABLE
C          ADIU                   - DUE IN UNSERVICEABLE
C          ADIT                   - DUE IN TOC
C          WNUM                   - WARTIME NUMBER OF USERS
C          ADREQ                  - ADDITIVE REQUIREMENT
C          DIVMAN                 - DIVISION AND ITEM MANAGER
C          SOR                    - SOR CODE #1
C          SOR88                  - SOR #1 PERCENT
C          SORCP                  - SOR CODES AND PERCENTS 2-7
C          PMC                    - PROCUREMENT METHOD CODE
C          URM                    - UNIT REPAIR MANHOURS
C          EQSPEC                 - EQUIPMENT SPECIALIST
C          PBPD                   - PEACETIME - BASE PROCESSED DAYS
C          PRI                                - REPARABLE INTRANSIT
C          PSTM                               - SOR TO MAINTENANCE
```

```
C        PSF                              - SHOP FLOW
C        PSIT                             - SERVICEABLE TURN-IN
C        WBPD                 - WARTIME - DEPOT PROCESSED DAYS
C        WRI                            - REPARABLE INTRANSIT
C        WSTM                           - SOR TO MAINTENANCE
C        WSF                            - SHOP FLOW
C        WSTI                           - SERVICEABLE TURN-IN
C        UD                   - UNSERVICEABLE DEPOT
C        UI                   - UNSERVICEABLE INTRANSIT
C
C================================================================
C================================================================
C
C   THE FOLLOWING IS A LIST OF VARIABLES USED
C   FOR DYNA-METRIC
C
C=======================================================
C
C        STOCKN              NAME OF PART (UNIQUE)
C        DDRP                DEMANDS PER FLYING HOUR-PEACETIME
C        FNRTS               FRACTION NRTS AT BASE NOT SUPPORTED BY CIRF
C        BNRTS               FRACTION NRTS AT BASE SUPPORTED BY CIRF
C        CNRTS               FRACTION NRTS AT CIRF
C        TTEST               TOTAL TEST OR REPAIR TIME(DAYS)
C        COST                COST OF ITEM
C        QPACFT              QUANTITY PER AIRCRAFT
C        CIRFP               CIRFP PART DESIGNATOR
C        RLIN                NON-LINEARITY FACTOR
C        VI                  VARIANCE TO MEAN RATIO
C        TOSTW               WARTIME ORDER AND SHIP TIME (DAYS)
C        TOSTP               PEACETIME ORDER AND SHIP TIME (DAYS)
C        RHO                 PROBABILITY LRU CANNOT BE REPAIRED IF TEST STAND
C                            HAS A BACKORDER
C
C=======================================================
C=======================================================
      CHARACTER ALC*2,STOCKN*15,NAME*10,IEC*3,SMC*4
      CHARACTER DIVMAN*3,SORCP*30,PMC*2,EQSPEC*2
      INTEGER REC,UPR,URC,ADL,PL,BRCD,DRCD,OSTD,DSLD,OSLD,DFSL,NUM
      INTEGERD041PK,WRMBR,VLD,WFD(14),WDRCD,WOST,MSL(13),PMJRP,EOMJRP
      INTEGER MMJRP,JRSLD,BPP(3),BDR(3),PJVP(3),PMRP(3),BRR(3),BCP(3)
      INTEGER EJVP(3),EMRP(3),DOCP(3),MWP(3),MMRP(3),TDR(3)
      INTEGER AS,AU,AO,AVSB,AWSD,AWOOF,AWOOC,ADIC,ADIW,ADIT,WNUM,ADREQ
      INTEGER SOR88,URN,PBPD,PRI,PSTM,PSF,PSTI,WBPD,WRI
      INTEGER WSTM,WSF,WSTI,UD,UI
```

```
      CHARACTER FILL*3,SOR*3
      INTEGER N(1200),ST(1200,6)
      CHARACTER*15 A(1200)
      J=0
      L=0
      REAL DDRP,FNRTS,BNRTS,CNRTS,TTEST,RLIN,VI,RHO
      INTEGER QPACFT,RRR,CIRFP,TOSTV,TOSTP
 1000 FORMAT(T1,I2,A2,A15,A10,I9,I9,I1,I2,2I3,3I2,2I3,
     &I7,I6,I2,12I4,A3,I3,I2,13I3,3I3,A4,I2,3I3,3I5,27I3,3I5)
 1010 FORMAT(T1,I2,3I9,8I6,I3,I6,A3,A2,I3,A30,A2,I6,A2,10I3,2I6)
 2000 FORMAT(T1,A16,T17,F7.5,T24,F5.3,T29,F5.3,T34,F5.3,
     &T39,F5.2,T44,F8.0,T52,I2,T54,I2,T56,I2,T58,F4.2,T62,F4.2,
     &T66,I3,T69,I3,T72,F5.3)
 2001 FORMAT(T1,'LOGRAM DATA BASE F-16 MAR 1982     ')
 2002 FORMAT(T2,'1',T3,'00.0000.00')
 2003 FORMAT(T3,'30  60  90 120 150 180 210 240 270')
 2004 FORMAT(T1,'OPT')
 2005 FORMAT(T6,'11  5')
 2006 FORMAT(T6,'12  5')
 2007 FORMAT(T1,'BASE')
 2008 FORMAT(T1,'BASE',T11,'0.0 0.0',T25,'0. 0. 1. 0. 0.11',
     &T42,'1. 0. 0. 0.99. 0.99. 0.')
 2009 FORMAT(T1,'ACFT')
 2010 FORMAT(T1,'BASE',T6,'613  30 533  60 501  90 486 120',
     &T38,'460 150 433 180 393 210 370 271')
 2011 FORMAT(T1,'SRTS')
 2012 FORMAT(T1,'BASE',T6,'0.0   1 2.0   9 1.0 271')
 2013 FORMAT(T1,'FLHR')
 2014 FORMAT(T1,'BASE',T6,'2.5 271')
 2015 FORMAT(T1,'TURN')
 2016 FORMAT(T1,' 3.5 271')
 2017 FORMAT(T1,'LRU')
 2018 FORMAT(T1,'STK')
 2019 FORMAT(T1,'STK',T17,A3,T22,'1')
 2020 FORMAT(T1,A16,T17,I3)
      QPACFT=1
      RRR=1
      CIRFP=1
      RLIN=1.0
      VI=0.0
      RHO=0.0
      BNRTS=0
      CNRTS=0
      WRITE(12,2001)
      WRITE(12,2002)
```

```
      WRITE(12,2003)
      WRITE(12,2004)
      WRITE(12,2005)
      WRITE(12,2006)
      WRITE(12,2007)
      WRITE(12,2008)
      WRITE(12,2009)
      WRITE(12,2010)
      WRITE(12,2011)
      WRITE(12,2012)
      WRITE(12,2013)
      WRITE(12,2014)
      WRITE(12,2015)
      WRITE(12,2016)
      WRITE(12,2017)
4     READ(11,1000,END=500,ERR=500) REC,ALC,STOCKN,NAME,UPR,URC,
     &ADL,PL,BRCD,DRCD,
     &OSTD,BSLD,OSLD,DFSL,NUM,DO41PR,VRMBR,VLD,(VPD(I),I=1,12),
     &IEC,VDRCD,VOST,(NSL(I),I=1,13),PMJRP,EONJRP,MMJRP,
     &SMC,JRSLD,(BPP(I),I=1,3),(DDR(I),I=1,3),(PJVP(I),I=1,3),
     &(PMRP(I),I=1,3),(BRR(I),I=1,3),(BCP(I),I=1,3),(EJVP(I),I=1,3),
     &(EMRP(I),I=1,3),(DOCP(I),I=1,3),(MVP(I),I=1,3),(MNRP(I),I=1,3),
     &(TDR(I),I=1,3)
      IF (REC.NE.0) GOTO 4
      READ(11,1010,END=500,ERR=500) REC,AS,AU,AO,AVSB,AVSD,AVUD,
     &AVOOF,AVOOC,
     &ADIC,ADIU,ADIT,VNUM,ADREQ,DIVMAN,SOR,SOR88,SORCP,PMC,URM,
     &EOSPEC,PBPD,PRI,PSTM,PSF,PSTI,VBPD,VRI,VSTM,VSF,VSTI,UD,UI
      J=J+1
      TOSTP=OSTD
      IF(TOSTP.LT.1.0) TOSTP=3.0
      TOSTV=23
      TTEST=BRCD*1.0
      IF(BRCD.EQ.0) TTEST=(BRR(1)+BRR(2)+BRR(3))/90.0
      DDRP=(TDR(1)+TDR(2)+TDR(3))/380.0/92000
      FMRTS=(1-((BPP(1)+BPP(2)+BPP(3))/380.0))
      COST=(UPR/100)*1.0
      IF(TTEST.LT.1.0) TTEST=1.0
      WRITE(12,2000)STOCKN,DDRP,FMRTS,BMRTS,CNRTS,TTEST,
     &COST,QPACFT,RRR,CIRFP,RLIN,VI,TOSTV,TOSTP,EHO
      A(J)=STOCKN
      IF(NUM.GT.0) AS=AS/NUM
      N(J)=AS
      DO 1 K=1,6
        ST(J,K)=NSL(K+3)
```

```
1       CONTINUE
        GOTO 4
500     CONTINUE
        WRITE(12,2018)
        DO 2 K=1,J
        WRITE(12,2020) A(K),N(K)
2       CONTINUE
        IF(L.EQ.1) GOTO 70
        WRITE(12,2019) ' 90'
        DO 10 K=1,J
        WRITE(12,2020) A(K),ST(K,1)
10      CONTINUE
        WRITE(12,2019) '120'
        DO 20 K=1,J
        WRITE(12,2020) A(K),ST(K,2)
20      CONTINUE
        WRITE(12,2019) '150'
        DO 30 K=1,J
        WRITE(12,2020) A(K),ST(K,3)
30      CONTINUE
        WRITE(12,2019) '180'
        DO 40 K=1,J
        WRITE(12,2020) A(K),ST(K,4)
40      CONTINUE
        WRITE(12,2019) '210'
        DO 50 K=1,J
        WRITE(12,2020) A(K),ST(K,5)
50      CONTINUE
        WRITE(12,2019) '240'
        DO 60 K=1,J
        WRITE(12,2020) A(J),ST(K,6)
60      CONTINUE
70      CONTINUE
        STOP
        END
$       EXECUTE
$       LIMITS:25,50K,,10K
$       PRMFL:12,W,S,83D010/THESIS12
$       TAPE9:11,X1D,,92281,,XR829
$       ENDJOB
```

```
C
C      THIS CREATE JOB CONTROL LANGUAGE PROGRAM
C      READS A TAPE (i.e. # 92281,,XRD29) FROM THE CREATE
C      LIBRARY AND PLACES THE INFORMATION IN
C      A PERMANENT CREATE FILE LIBRARY FOR THE
C      GIVEN CREATE ACCOUNT NUMBER (i.e.83D010/DATA2)
C
C      USING NOTES:
C                 1. THE NAME ON THE TAPE SHOULD AGREE
C                    WITH THE NAME IN THIS PROGRAM (i.e. XRD29)
C                    OR THE CONSOLE OPERATOR MAY ABORT THE
C                    PROGRAM.
C                 2. THE NAME GIVEN TO THE FILE ON THE ACCOUNT
C                    NUMBER MUST ALREADY BE IN EXISTANCE OR
C                    THE PROGRAM WILL SELF ABORT
C                 3. DELETE ALL THES COMMENTS PRIOR TO RUNNING.
$      IDENT   WP0354,AFIT/LS(SPROULL)
$      UTILITY
$      FUTIL   IN,OT,COPY/1F/
$      TAPE    IN,X1D,,92281,,DATA1
$      PRMFL   OT,W,S,83D010/DATA2
$      ENDJOB
```

SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

1. Air Force Logistics Command. Logistics Systems Training Program: Recoverable Consumption Requirements System (D041). Wright-Patterson AFB OH: Air Force Logistics Command, 1980.

2. Brantley, Captain Jim S.,USAF, and Captain Donald E. Loreman, USAF. "A Comparative Analysis of the D041 Single Moving Average and Other Time Series Analysis Forecasting Techniques." Unpublished master's thesis. LSSR 7-77A, AFIT/LS, Wright-Patterson AFB OH, June 1977. AD A044078

3. Christensen, Captain Bruce R.,USAF, and Gene J. Schroeder, GS-12. "A Comparative Analysis of the D041 System and Time Series Analysis Models for Forecasting Reparable Item Generations." Unpublished Master's Thesis. SLSR 27-76B, AFIT/LS, Wright-Patterson AFB OH, September 1976. AD A032364

4. Collier, Michael. Plans Analysis Specialist,XRPA, AFLC Headquarters. Personal interviews, January 1983 to 8 August 1983.

5. Demmy, W. Steven and Jon R. Hobbs. "Dyna-METRIC: an Overview." Air Force Journal of Logistics, Spring 1983, pp. 14-17.

6. Duke, 1st Lt. James A.,USAF, and 1st Lt. Kenneth W. Elmore, USAF. "An Empiracal Investigation of the Effects of Inventory Stockage Models for Recoverable Items on Weapons System Availability." Unpublished master's thesis. LSSR 14-81, AFIT/LS, Wright-Patterson AFB OH, June 1981. AD A103255

7. Feeney, G.J. and C.C. Sherbrooke. The (S-1,s) Inventory Policy under Compound Poisson Demand: a Theory of Recoverable Item Stockage. Rand Corporation, RM-4176-FR, Santa Monica CA, 1964.

8. General Accounting Office. "More Credibility Needed in the USAF Requirements Determination Process." Unpublished research report, unnumbered, General Accounting Office, Washington DC, 1982.

9. Golden, Robert. F. "The Combined Logistics Model: Concept and Identification Phase," Unpublished research report, unnumbered, Air Command and Staff College, Maxwell AFB AL, 1978.

10. Hillestad, R.J. and M.J. Carrillo. Models and Techniques for Recoverable Item Stockage when the Demand and Repair Process are Non-stationary: Part I: Preformance. Rand Corporation, N-1482-AF, Santa Monica CA, 1980.

11. ________. Dyna-METRIC: Dynamic Multi-Echelon Technique for Recoverable Item Control. Rand Corporation, WD-911-AF, Santa Monica CA, 1981.

12. Muckstadt, J.A.. Comparative Adequacy of Steady-State versus Dynamic Models for Calculating Stockage Requirements. Rand Corporation, R-2636-AF, Santa Monica CA, 1980.

13. ________. "A Model for Multi-Echelon, Multi-Indenture Inventory System," Management Science, December 1973, pp. 472-481.

14. Pyles, Raymond and Robert Tripp. Measuring and Managing Readiness: The Concept and Design of the Combat Support Capability Management System. Rand Corporation, N-1840-AF, Santa Monica CA, 1982.

15. ________. "Measuring and Managing Readiness: An Old Problem-A New Approach." Air Force Journal of Logistics. Spring 1983, pp. 18-24.

16. Raether, Thomas. Plans Analysis Specialist, XRPA, AFLC Headquarters. Personal interviews, January 1983 to 5 August 1983.

17. Sherbrokke, Craig C. METRIC: A Multi-echelon Technique for Recoverable Item Control. Rand Corporation, RM-5078-PR, Santa Monica CA, 1966.

18. Tyler, Paul E. "Sensitivity Testing of Dyna-METRIC" Unpublished research report, 82-0970, Air Command and Staff College, Maxwell AFB AL, 1982. AD B066979

19. U.S. Department of the Air Force. Logistics Long Range Planning Guide. Washington DC, 21 January 1981.

20. XRPA, "LOGRAM Reference Manual," Unpublished reference report, unnumbered, AFLC, Wright-Patterson AFB OH.

B. RELATED SOURCES

Brooks, Robin B.S., Colleen A. Gillen, and John Y. Lu. Alternate Measures of Supply Performance: Fills, Backorders, Operational Rate, and NORS. Rand Corporation, RM-6094-RR, Santa Monica CA, August 1969.

Crawford, G. B. Palm's Theorem for Nonstationary Processes. Rand Corporation, R-2750-RC, Santa Monica CA, October 1981.

Denman, Julia C.,GS-12, Captain John Gavel, USAF, and Captain Perry L. Sholer, USAF. "An Inquiry into the Possible Effects of Implementation of the Variable Safety Level Technique of the D041 System on WRM Items in Terms of NORS(G) Incidents and Hours," Unpublished master's thesis, SLSR 25-76B, AFIT/LS, Wright-Patterson AFB OH, September 1976.

Gage, Dr. Thomas W. and Captain Andrew J. Ogan, USAF. "Dyna-METRIC: A Valuable Management Tool." Air Force Journal of Logistics. Spring 1983, pp. 22-24.

Hillestad, R, J. Dyna-metric:Dynamic Multi-Echelon Technique for Recoverable Item Control. Rand Corporation, WD-911-AF, Santa Monica CA, September 1981.

Kutzke, Captain Jonathan H., USAF, and Gary A. Turner,GS-13 "The Effects of Item Usage Variation on Inventory Systems." Unpublished master's thesis. LSSR 77-82, AFIT/LS, Wright-Patterson AFB OH, September 1982.

END

FILMED

1-84

DTIC